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Analysis of ULF/VLF Ambient Noise Measurements During SWAPP

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During March of 1990, the Physical Oceanography Wave Processes ARI sponsored a major experiment whose goal was the elucidation of the physical processes controlling ocean waves. This experiment included instrumentation for measureing the surface manifestation of several processes (the ocean wave field itself and the breaking of waves) known to be contributors to sea-floor noise. With NOARL and MPL ARL funds, this experiment was augmented with measurements of the noise field on the sea floor so that the generation processes can be related to the sea floor noise in a quantitative way.

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Analysis of ULF/VLF Ambient Noise Measurements During SWAPP

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Background:

During March of 1990, the Physical Oceanography Wave Processes ARI sponsored a major experiment whose goal was the elucidation of the physical processes controlling ocean waves. This experiment included instrumentation for measuring the surface manifestation of several processes (the ocean wave field itself and the breaking of waves) known to be contributors to sea-floor noise. With NOARL and MPL ARL funds, this experiment was augmented with measurements of the noise field on the sea floor so that the generation processes can be related to the sea floor noise in a quantitative way.

The two-dimensional OBS array deployed during the ONR-sponsored CIRCUS experiment provided the first short-range coherence information addressing the structure of sea-floor noise. Our analysis of these correlation lengths (Schreiner and Dorman, 1990) shows that interface waves are important contributors to the noise field and that the relative excitation of the several gravest modes is consistent with scattering into the sea-floor waveguide. Although that experiment indicated the propagation path, the environmental control, specifically wave measurements, were not available to allow determination of the absolute energy of the excitation from the ocean waves.

The noise source which is the closest to the sea floor (and most energetic) is the sea surface, where energy exchange with the atmosphere takes place. Seismic data from several Ocean Bottom Seismology experiments show that sea floor noise is correlated with swell (in the 0.05 Hz-0.5 Hz band) and with local wind (in the 0.5 Hz-30 Hz band).

The widely accepted noise mechanism in the lower of these two bands is the wave-wave interaction which transfers energy from ocean surface waves to acoustic/seismic energy. In the higher band, the spectrum of sea floor noise shows the same saturation behavior as does the surface wave spectrum except at times of high winds.

The quantitative evaluation of of the nonlinear wave-wave interaction mechanism requires the evaluation of an integral containing the wavenumber spectrum of the surface waves. There is currently no easy method for measuring this spectrum. Scattering of radio waves has been used for measurements at long wavelengths but the most practical method available now is high-frequency doppler sonar, which should provide f-k spectra in the range 0.05-0.5 Hz (corresponding to wavelengths in the range 6-1600 meters). The SWAPP field program (J. Smith and R. Pinkel) incorporated these sonars.

In the high frequency band, noise stemming from the breaking of waves becomes important, and this is currently the subject of active work. The SWAPP field program included measurements of the incidence of wave breaking using radar measurements (K. Melville) and observations from below of the distribution of bubbles entrained by those processes (D. Farmer). Farmer's instruments are freely floating buoys with up-looking sonar profilers. These were allowed to drift

through the area (1-2 km in size) insonified by the doppler sonar systems.

Approach

We augmented SWAPP with a sea floor OBS array, useful in the frequency range 0.05-30 Hz, and consisting of 14 instruments. Each OBS recorded 4 channels of data - vertical and two horizontal components of displacement and pressure from a hydrophone. They were employed in an array with spacings in the 10 - 75 m range to measure spatial coherences in that range. Additionally, 4 conventional OBSs and an autonomous bottom-moored hydrophone array from NOARL were deployed. Those data are also available to us to calculate coherences at larger offsets. Small explosions were fired on the sea floor generated dispersed interface waves to give us the sea-floor shear velocity structure.

Progress To Date

Last year the ONR ARL program supported the initial studies of data from the SWAPP experiment. Since that time we have made significant progress. We have made charts of the bathymetry and of the sediment thickness (figures 1 and 2) and have located the shots and autonomous OBSs (figure 3). We have have made progress in the location of the telemetered OBSs which were deployed from the USNS DESTEIGUER but have been hampered by interference from asynchronous pings from an independent ship-navigation system.

Figure 4 shows dispersion analyses of representative Stoneley wave seismograms and figure 5 shows the shear velocities derived from them. It is interesting to note that the shallow shear velocities at the SWAPP site (400 km west of the continental edge) are somewhat higher than the velocities at similar depths at the CIRCUS site (at the edge of the Patton Escarpment). Two publications are now in press. Schreiner and others (1991) presents a study of 15 Stoneley wave dispersion seismograms recorded at ranges between 0.4 and 1.6 km in range. These dispersion curves could be classified into 3 types, and the boundaries between these types of seafloor are roughly parallel with the grain of the seafloor topography. Bibee and Dorman (1991) discuss interface wave energetics, variability and compare geophones and hydrophone sensors.

The SWAPP experiment provided a unique opportunity to obtain environmental data completely characterizing the parameters believed to be responsible for sea floor ambient noise in the 0.05 - 30 Hz region. By analyzing the acoustic and seismic sea floor measurements beneath the SWAPP instruments, a great deal will be learned about the ULF/VLF ambient noise field.

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